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(54) Apparatus for holding a substrate during polishing

(57) A wafer polishing head (100) utilises a wafer backing member (124) having a wafer facing pocket (126) which is sealed against the wafer and is pressurised with air or other fluid to provide a uniform force distribution pattern across the width of the wafer inside an edge seal feature (123) at the perimeter of the wafer to urge (or press) the wafer uniformly toward a polishing pad (182). Wafer polishing is carried out uniformly without variations in the amount of wafer material across the usable area of the wafer. A frictional force between the seal feature (123) of the backing member and the surface of the wafer transfers rotational movement of the head to the wafer during polishing. A pressure controlled bellows (118) supports and presses the wafer backing member (124) toward the polishing pad (182) and accommodates any dimensional variation between the polishing head and the polishing pad as the polishing head is moved relative to the polishing pad. An integral, but independently retractable and extendable retaining ring assembly (146) is provided around the wafer backing member and wafer to uniformly an independently control the pressure of a wafer perimeter retaining ring (162) on the polishing pad (182) of a wafer polishing bed (180).

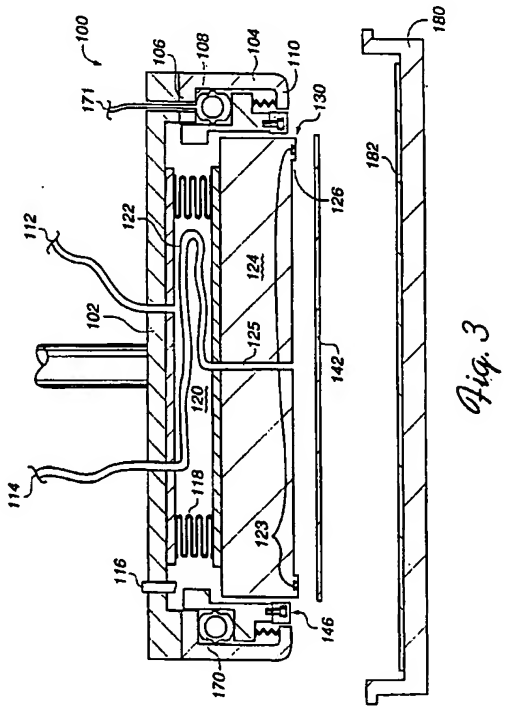

Fig. 3

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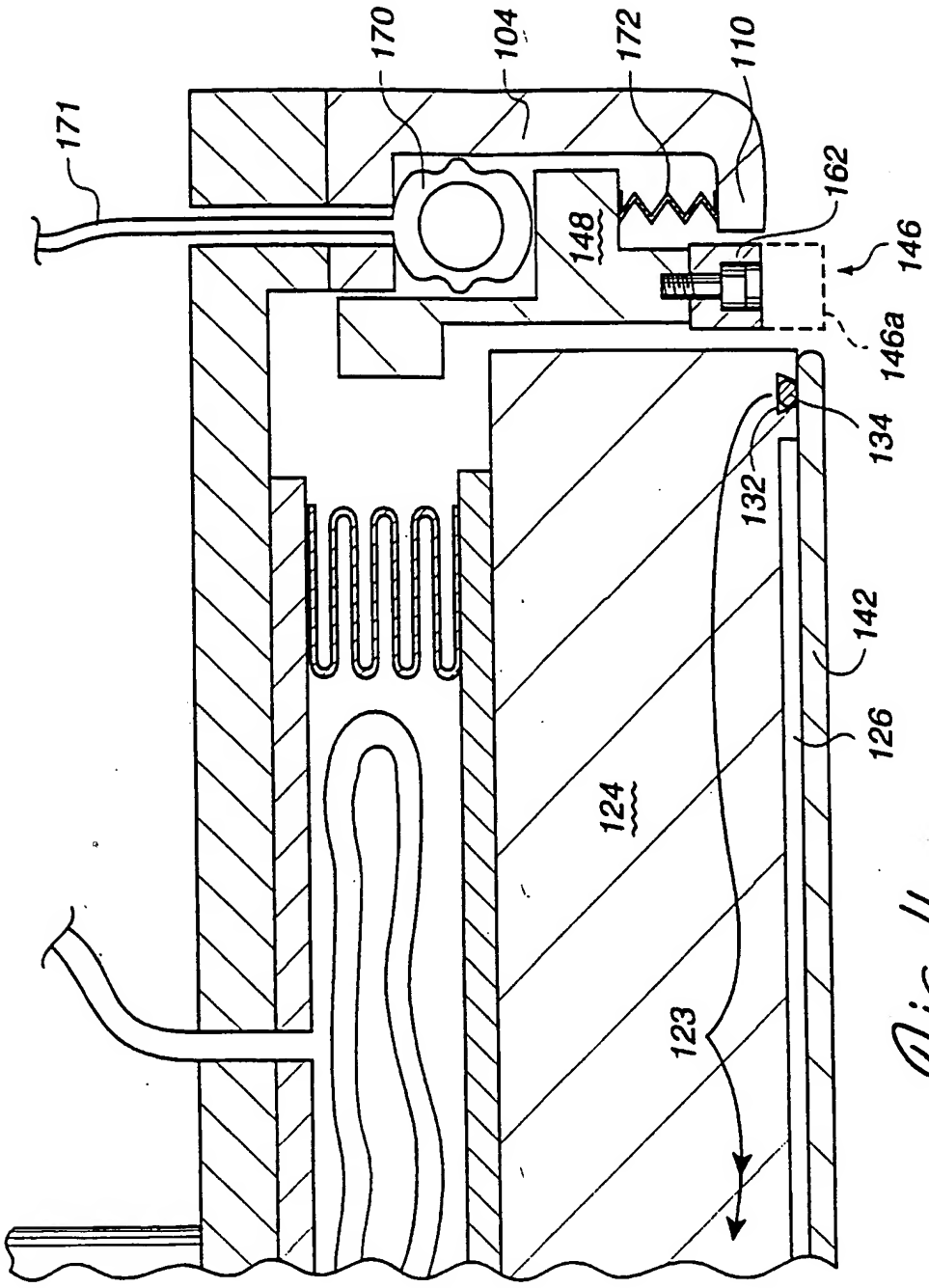

Fig. 4

Description

This invention relates generally to mechanical polishing and in particular it relates to polishing heads used to polish generally circular semiconductor wafers in the semiconductor industry.

This invention provides improved construction and easier operability of polishing heads useful for positioning a substrate, in particular, a semiconductor substrate, on the surface of a polishing pad. Such heads also provide a controllable biasing, or loading, between the surface of the substrate and the polishing surface.

A typical substrate polishing apparatus positions a surface of a substrate against a polishing surface. Such a polishing configuration is useful for polishing the substrate after it has been sliced from a boule (single crystal), to provide smoothly planar, parallel, front and back sides thereon. It is also useful for polishing a surface of the substrate on which one or more film layers have been deposited, where polishing is used to planarize the surface of the substrate on which one or more film layers have been deposited. A slurry having both chemically reactive and abrasive components is used in conjunction with the positioning of the film layer surface against a moving polishing surface to provide the desired polishing. This is known as chemical mechanical polishing.

A typical wafer polishing apparatus employs a carrier, or polishing head, to hold the substrate and position the film layer surface of the substrate against a polishing surface. The polishing surface is typically provided by placing a large polishing pad, typically as large as one meter in diameter, on a massive rotatable platen. The platen is driven by a motor, to rotate the polishing pad and thus provides relative motion between the pad and the film layer surface of the substrate. As the pad rotates, it tends to pull the substrate out of the carrier. Therefore, the carrier also typically includes a recess within which the substrate is received. This recess is commonly provided by extending a retainer downwardly from the substrate receiving surface ofthe carrier positioned adjacent to, and extending circumferentially around, the edge of the substrate. The apparatus also provides a means for positioning the carrier over the polishing pad and biasing the carrier towards the pad to load the substrate against the pad, and a drive means for providing rotational, vibratory or oscillatory motion to the carrier.

An example of a polishing head having a retaining ring is shown in U.S. Patent No. 5,205,082, by Shendon et al. which discloses pressurized diaphragm arrangement which urges a wafer carrier and wafer retainer toward a polishing pad.

Figures 1 and 2 disclose several polishing head configurations developed by applicants' assignee, and which are the subject of United States patent applications commonly owned by applicants' assignee. Figure 1 discloses: a polishing head 20 having an upper plate 22 for attachment of the carrier 20 to a drive member, a downwardly extending outer wall 24 which terminates in a spring loaded retainer ring 30, and a wafer backing member 42 which is connected to the upper plate 22 by a bellows 38 and is received within the wall 24 and ring 30. The lower surface of the backing member 42 receives a conformable pad material 48 thereagainst, against which the substrate 50 is received for polishing. The retaining ring 30 circumscribes the edge of the substrate 50, and is connected to the lower terminus of the outer wall 24 in a tongue and groove connection 26. This connection also includes a spring 28, which bears upon the upper surface 32 of the ring 30 to bias the ring downwardly from the wall 24.

The head 20 is received on a polishing pad 52 located over a rotatable platen 54, on which a slurry 53 may be provided. To provide the biasing, or loading, of the substrate against the polishing pad 52, a passage 34 extends into the chamber 39 defined by the bellows 38, the upper wall 22 and the upper surface of the backing member 42. When air, or other fluid, is supplied to the chamber 39 under pressure, the backing plate 42 is urged downwardly, to bias or load the substrate against the polishing pad. The backing member 42 also includes a chamber 45 therein, which is defined by the walls ofthe backing member 42, and which may be pressurized by supplying a fluid, under pressure, through a passage defined by port 36, hose 40 extending through the chamber 39, and to a port 44 which opens into chamber 45. When this second chamber 45 is pressurized, it differentially expands a flexible bottom wall 46 of the backing member 42, to provide more loading at the center of the substrate as compared to loading occurring at the edge of the substrate. This design provides a solution to one problem commonly associated with chemical mechanical polishing: The tendency of the edge of the substrate to be polished more rapidly than the center of the substrate. By providing a greater load at the center of the substrate, the polishing rate at the center of the substrate may be increased to balance the polishing rate at the edge of the substrate.

Figure 2 shows an alternate arrangement for generally uniformly clamping a wafer 72 being polished to the polishing pad 52, which is described in a U.S. Patent Application (serial no. 08/205,276 filed 3/2/94 which is a CIP of 08/173,846 filed 12/27/93) also owned by applicants' assignee. The polishing head 58 of Figure 2 includes a descending skirt 60 with a retaining ring 68 like the retaining ring of the configuration of Figure 1 (connection details are not shown). A bladder lining 70 lines the cavity 62 inside the descending skirt 60 and also spans the bottom opening of the cavity 62 so that wafer 72 being polished directly contacts the lower surface of the bladder 70. The polishing head 58 is vertically fixed to a polishing arm (or member). Variations in clearance between the vertically fixed arm (not shown) and the polishing pad 52 are accommodated by providing a constant fluid pressure to the interior of the bladder. The bladder while maintaining a constant pressure locally

expands and contracts according to the variations in clearance as the polishing head moves relative to the polishing pad 52. A limit plate 64 is provided inside the cavity of the bladder 70 to prevent the face of the bladder bottom surface from collapsing when the bladder is not pressurized. Since the bladder edge (perimeter) is fixed to the inside surface of the descending wall 60, the edge of the bladder 70 does not move with variations in clearance (between the arm and polishing pad). Because the edge of the bladder does not move, it can create an undesirable edge effect (a variation in the amount of material removed at the center of the wafer when compared to the amount of material removed at the perimeter adjacent to the edge of the bladder). The friction and/or an electrostatic charge between the surface of the bladder and the surface of the wafer helps to assure that the wafer rotates with the head when it is rotated.

In the configuration of Figures 1 and 2, the force urging the retaining ring toward the polishing pad is dependent on the predetermined spring constant of the circular leaf spring 28 and its compression. The retaining rings 30 and 68 of Figures 1 and 2 are subject to bending and torsional deflection due to the spring configuration which does not provide a continuous contact force but provides a series of point loads, clamping the ring to the polishing pad. The retaining ring bends and deflects because it is allowed to flex between these point loads. This flexing can cause variation in the clearance between the ring and pad which affects the depth of slurry that passes under the ring, and it also affects the pad compression adjacent to the edge ofthe wafer. Variations in the depth of polishing slurry and in pad compression adjacent to the edge of the wafer can cause differential polishing of the wafer to the detriment of polishing uniformity.

The object in each head configuration is to provide a fixture which will uniformly polish the wafer across its full width without unacceptable variations in the thickness of the wafer. These prior art configurations as described can introduce polishing variations due to bladder edge effects, non-uniformly distributed force pressing the wafer to the polishing pad, and retaining ring deflections which require close and frequent monitoring to assure satisfactory polishing results.

This invention relates to a polishing head substrate (wafer) backing member facing the back of, and being sealed to, a substrate (wafer) being polished. The wafer is sealed to a cavity located in the member around the perimeter of the cavity and a fluid (preferably gas although it may be a liquid) pressurizes the cavity and the back of the wafer against a slurry containing polishing pad.

The wafer backing member preferably includes a seal feature, e.g. an O-ring, lip seal, or other seal member which extends from the backing member adjacent to the perimeter of the backing member to form a recess between the wafer and the member to hold a fluid or gas in the recess behind the wafer to provide a uniform pressure across the surface of the wafer being pressed against the polishing pad. A gas tight bellows chamber supports the wafer backing member and urges it toward the polishing pad to provide primary loading of the substrate against the pad. When the bellows is pressurized to urge the substrate against the polishing pad, it compresses the seal. Simultaneously, the pressure in the cavity formed by the seal may be changed, to selectively vary the polishing of the substrate. The cavity may be evacuated, to urge the center of the substrate away from the pad to increase polishing at the substrate edge as compared to its center, and it may be pressurized to enable uniform loading of the substrate against the pad. The pressure in the cavity urges the substrate away from the holding member, and thereby decompresses the seal. The pressure in the cavity may be sufficiently large to separate the substrate from the seal, at which point the cavity pressure will release, or "blow-by," through the resulting gap between the substrate and the seal.

In a further aspect of the invention, a retractable and pressure extendable retaining ring assembly extends around the backing member and prevents the wafer from sliding out from below the surface ofthe substrate backing member. An annular ring extending bladder extends along the backside of the ring, the bladder when pressurized urges the ring against the pad. The force with which the retaining ring is clamped to the polishing pad is dependant on the gas pressure maintained in this bladder.

These inventive configurations, alone or in combination, provide several advantages. One advantage is direct control of a uniform force on the back surface of the wafer being polished within the perimeter of the seal extending between the holding member and the wafer. A pressure is uniformly maintained without the complication or edge effects of an intermediate bladder in direct contact with the substrate. Another advantage is that the total force pressing the wafer backing member toward the wafer is controlled separately by the force created by controlling the pressure within the bellows completely independent of the influence of the pressure cavity formed between the wafer and the backing member. If the force on the wafer due to the pressure behind the wafer in the wafer facing cavity exceeds the force on the seal to the wafer exerted by the pressure in the bellows then the wafer will lift away from its seal and seal blow-by will occur until equilibrium restores the seal.

The pressure within the wafer facing cavity controls the distribution pattern by which this total force is transmitted from the wafer backing member to the wafer. Providing a vacuum to the cavity can cause the center of a supported wafer to bow inward, so that only a perimeter polishing contact is achieved. In contrast, positive pressure in excess of the seal contact pressure will cause the wafer to lift off (move away from) the seal and for gas to blow-by (it cannot cause outward bowing of the

substrate as the pressure at the center of the substrate can never exceed the pressure at the perimeter of the substrate), and will also cause a uniform pressure on the back of the wafer. The bowing or deflection of the wafer, if any, is controlled and limited by the pressure on the perimeter seal, so long as the internal pressure of the recess or cavity facing the wafer does not exceed the seal pressure and cause seal blow-by.

This configuration according to the invention nearly guarantees that, as long as the force provided by the backing pressure urging the wafer from the seal is maintained at or slightly below the pressure on the seal provided by the bellows, the force clamping the wafer to the polishing pad for polishing will be uniform across the area of the wafer. In reality, because it is desired to maintain a gas tight perimeter seal, in operation the pressure in the wafer facing cavity will be slightly less than the pressure at which seal blow-by occurs. Under these conditions, a slightly greater pressure will be present between the substrate and the pad at the seal location which will slightly increase the polishing (material removed) in the perimeter ring (seal) area. However, the outer three millimeters of the substrate are considered to be a non-usable handling margin and therefore slight additional polishing (material removed) in this narrow band at the edge of the substrate is not considered deleterious.

The extension and retraction of the wafer retaining ring assembly is independently controlled by the use of the continuous annular bladder positioned around the perimeter of the wafer backing member. Such a configuration can eliminate the pressure variations associated with the point contacts of springs provided to urge the ring into contact with the pad. In one configuration, one or more restoring springs are supported on a rigid portion of the retaining ring backing ring to cause the retaining ring to retract from its lowered position when the extension bladder is depressurized.

The frictional force between the seal at the perimeter of the wafer backing member is sufficient such that when the polishing head is rotated during polishing while the wafer is in contact with the polishing slurry on the polishing pad there is sufficient frictional force that the wafer rotates with the polishing head and overcomes the resistance to rotation with the head due to the motion of the pad and the polishing media on the polishing pad.

The following is a description of some specific embodiments of the invention, reference being made to the accompanying drawings, in which:

Figure 1 is a cross section of a polishing head with a pressurized bellows chamber pressing a floating hollow wafer backing disk having a flexible bottom and pressing the water being polished against the polishing pad:

Figure 2 shows a cross section of a polishing head using a pressurized bladder with a wafer retaining ring attached to the circumference of the polishing head;

Figure 3 shows a cross section of an embodiment according to the invention;

Figure 4 shows a close up view of the right side of Figure 3 showing the periphery of the wafer backing member with an O-ring seal; and

Figure 5 shows a close up of the right side of Figure 3 showing the periphery of the wafer backing member with a lip seal.

A polishing head assembly 100 in a configuration according to the invention is shown in Figure 3. The polishing head assembly 100 includes a polishing head housing support plate 102 which is integral with its rod or stem support member. This polishing head housing support plate 102 is generally circular so as to match the circular configuration of the wafer to be polished. A polishing head housing descending wall 104 is attached to the bottom of the support plate 102 by a descending wall top flange 106. The descending wall 104 includes a lower lip 110 which curves inward toward the wafer 142 to be polished. The descending wall 104 encloses a wafer perimeter retaining ring assembly 146 enclosing a wafer (substrate) backing member (disk) 124. The wafer backing member 124 is attached to the polishing head housing support plate 102 by a bellows 118 which allows a vertically variable vacuum seal. The bellows 118 enclose a bellows chamber 120. The bellows chamber 120 can be pressurized positively or negatively through a gas passage 112 to the inside of the bellows.

An Overview of the Apparatus

One typical substrate polishing apparatus generally includes a large rotating polishing pad, typically larger than, and more typically several times larger than, the surface area of the substrate being polished. Also included is a polishing head within which the substrate is mounted for positioning a surface of the substrate against the polishing surface. The head is typically supported over the pad, and fixed relative to the surface of the pad, by a support member. This support member provides a fixed bearing location from which head may extend to provide a desired unit loading of the substrate against the pad. Loading means to enable this loading of the substrate against the polishing pad include hydraulic and pneumatic pistons which extend between the polishing head 100 and the support member (not shown). Additionally, the head 100 will also typically be rotatable, which enables rotation of the substrate on the pad. Likewise, the pad is typically rotated, to provide a constantly changing surface of the pad against the substrate. This rotation is typically provided by separate electric motors coupled to the head and a polishing platen on which the pad is received.

The polishing head assembly 100 of the present invention provides a mechanism to position a wafer 142 on a polishing pad 182, and to uniformly load the surface

of the wafer 142 to be polished against the pad 182. Generally, the head assembly (carrier) 100 can be considered to comprise three systems: a loading member which supplies the downward loading ofthe wafer against the polishing surface; a mounting portion which allows a uniform pattern loading of the wafer against the polishing surface; and a retaining assembly which ensures that the wafer will not slip out from the mounting portion (carrier) during polishing operations. Each of these three members or systems provide improvements in carrier head designs, and may be used independently or in combination.

The loading member generally comprises the bellows.118 and the bellows chamber 120 provided by the attachment of the bellows to the upper surface of the backing member 124 and the interior of the support plate 102. By pressurizing the chamber 120, force is exerted on the backing member 124, and thus on the wafer 142, to load the wafer 142 against the polishing surface of the polishing pad 182. The mounting portion includes a separate sealed pocket 123, one wall of which is formed by the wafer, to provide an even, hydrostatic, loading across the backside of the wafer. The retainer assembly 146 includes the extendable retainer 162 which circumscribes the wafer 142, to ensure maintenance of the wafer 142 on the head 100.

The Structure of the Loading Member and the Mounting Portion

To provide the wafer mounting member, the wafer backing member 124 includes the pocket 123 (including a wafer facing recess 126) whose perimeter is configured to receive an edge seal feature 130, e.g., an O-ring (not shown in the empty O-ring groove of Figure 4) or other type of seal. The edge seal 130 is located and configured to engage the backside of the wafer 142 and thereby form in combination with the recess 126, a pressurizable pocket 123 (within the perimeter of the perimeter vacuum seal including the recess 126 and the area within the seal 130 over the backside ofthe wafer. When the backing member 124 is rotated, this feature provides a frictional force between the substrate being polished 142 and the backing member 124 so that the substrate 142 generally turns with the backing member 124. Gas or other fluid (preferably an inert gas) is applied to or evacuated from the pocket through a gas passage 125 as connected through a hose 122 coiled inside the bellows 118 and supplied from a gas passage 114. The selective pressurization of the pocket 123 and the bellows chamber 120 provides the loading of the wafer on the polishing pad 182. Additionally, the bellows enables the backing member 124, and thus the wafer 128, to move rotationally with respect to the housing support plate 102 and in the x, y, and z directions during polishing.

The bellows 118, in combination with the upper surface of the backing member 124, the lower surface ofthe support plate 102 and a pressure source, provide the loading member. In one mode of operation, the pressure in the bellows chamber 120 is controlled to be constant and the flexibility of the bellows 118 accommodates misalignments or changes in clearance between the wafer backing member 124 and the surface of the polishing pad 182 located in a stationary or rotating polishing bed 180. The bellows chamber 120 pressure is selected to provide the desired loading of the wafer 142 against the polishing pad 182. In this configuration, the contact pressure in the bellows chamber 120 provides a regulatable uniform force pressing the wafer backing member 124 toward the surface of the polishing pad 182 regardless of the extension of the bellows 118.

In turn, pressurizing the wafer facing recess 126 behind the wafer 142 enables a uniform contact pressure to exist between the polishing pad 182 and the wafer 142 across the entire surface of the wafer contacting the polishing pad 182.

The extension or retraction of the bellows 118 is controlled by pressurizing or depressurizing the bellows cavity 120 via the gas passage 112. The pressurization or depressurization of the wafer facing recess 126 in the wafer backing member 124 either pressurizes or depressurizes the pocket 123 sealed by the seal feature 130 and the wafer 142 such that differential pressure due to vacuum bends the wafer 142 upwardly or positive pressure creates a separating force greater than the sealing force acting on the seal feature 130 by the pressure in the bellows 118 and forces the wafer from its seals.

The head configuration of Figure 3 also overcomes the comparative difficulty encountered in prior art head designs when loading and unloading the wafer from the head, and ensuring that the wafer does not slip from the head as the head 100 is positioned on the polishing pad 182.

In the present head design, the pressure maintained in the pocket may be changed to provide a superatmospheric pressure to separate the wafer from the carrier when polishing is completed, and to provide a vacuum pressure (preferably ofup to approximately 100 torr less than atmospheric pressure) behind the wafer thereby causing atmospheric pressure to maintain the wafer on the head as the head is loaded onto the polishing pad 182.

When the wafer is attached to the backing member 124 by maintaining a vacuum in the pocket, the wafer may deflect inwardly toward the recess 126. To limit the deflection of the wafer, the recess 126 is sufficiently shallow that the total possible deflection of the wafer inwardly of the recess, when considered in combination with the span of the wafer 128 across the recess 126, will impose stresses in the wafer 126 which are less than the strength or yield limits of the wafer material.

The vacuum need be maintained in the pocket only during the period of time that the head is removed from the polishing pad 182. Once the head, and thus the wafer 128, are repositioned on the polishing pad 182, the

pressure in the pocket is increased, until a pressure above atmospheric pressure is maintained therein. Simultaneously, the pressure in the bellows chamber 120 is increased, to provide a load force to load the wafer 128 against the polishing pad 182.

As the pressure in the bellows chamber 120 is increased, it loads the seal 130 received in the backing member 124 into contact with the backside of the wafer. The seal will compress under this load, which will enhance the sealing characteristics of the seal 130. Therefore, as the pressure in the bellows chamber 120 increases, the threshold pressure at which gas maintained in the pocket 123 will leak past, or "blow-by", the seal 130, also increases. Blow-by occurs when the head and seal 13 lift off the wafer, this condition occurs when the pressure in the pocket, when multiplied by the surface area of the wafer 128 circumscribed by the seal 130, exceeds the load force on the seal-wafer interface. In the configuration of the head, as shown in Figure 3, the area of the backing member 124 which is circumscribed by the bellows 118 is smaller than the area of the wafer 128 circumscribed by the seal 130. Therefore, the pressure in the bellows cavity must exceed the pressure maintained in the pocket to prevent blow-by.

Preferably, the pressure maintained in the pocket is approximately 75 torr less than the threshold at which blow-by will occur. At these pressures, the entire backside of the wafer, less a very small annular area outward of the seal 130, will have a uniform pressure on the back surface thereof which ensures that the front surface of the wafer is uniformly loaded against the polishing pad 182. However, it is specifically contemplated, although not preferred, that higher pressures, including a pressure at or above blow-by, may be used. Where such higher pressures are used, the seal-wafer interface will serve as a relief valve, and blow by will occur periodically to maintain a desired pressure within the pocket 123.

Figure 4 shows a close up ofthe right side of the polishing head of Figure 3. The seal feature 130 in this figure is an O-ring 134 located in a O-ring groove 132 (i.e. collectively: an annular extending portion). This seal is located at the perimeter of the wafer 142 surrounding the wafer facing recess 126 (and the associated pocket). The perimeter of the wafer backing member 124 is surrounded by a wafer perimeter retaining ring assembly 146, which generally includes a wafer perimeter retaining ring 162 attached to a wafer perimeter retaining ring backing ring 148. A series of compression springs 172 (i.e. a first set of elastic members) support the backing ring 148 on the lip 110 of the descending wall 104. An expandable retaining ring extending bladder 170 can be pressurized through gas supply passage 171 (i.e. a second set of elastic members). When pressurized, the retaining ring assembly 146 is extended to a location adjacent the wafer 142 as shown by the dash lines 146a in Figure 4.

A second configuration of the polishing head of the present invention is shown in Figure 5, wherein the seal 130 is replaced with a downwardly extending lip seal 136 received on the outer perimeter of the backing member 124, and is secured thereon by a backing ring 138 extending about the outer circumference ofthe lip seal 136. The lip seal 136 is preferably a thin, elastic, member having a rectangular cross section. A portion of the seal 138 extends from the underside. or wafer engaging side, of the backing member 124, to engage the upper surface ofthe wafer 128 immediately inwardly ofthe perimeter of the wafer 128. As with the seal 130, the engagement of the seal 136 with the wafer forms a pocket (includes wafer recess 126 and shoulder area inside lip seal) which may be evacuated or pressurized. The elastic seal, just as did the O-ring 134 in the configuration of Figures 3 and 4, provides sufficient contact between the surface of the substrate and the surface of the seal to create a rotational force due to friction between the two to keep them in contact so that the substrate turns with the head.

The Retaining Ring

Referring again to Figure 3, the head 100 also includes a retaining assembly 146 to ensure that the wafer 142 does not slip out from behind the head during polishing operations. The wafer perimeter retaining ring assembly 146 includes a wafer perimeter ring 162 having through holes 164 and counterbores 166 therein (Figure 5). Retaining ring screws 168 are placed therethrough and threaded into a series of backing-ring bottom- surface threaded holes 160 to hold the retaining ring 162 to the wafer perimeter retaining ring backing ring 148. The retaining ring 162 is preferable made of Delrin or similar plastic material while the backing ring 148 is preferably made of aluminum as are all of the other metal pieces except for the bellows which is stainless steel. The backing ring 148 has a bottom surface 158 facing the retaining ring 162. The backing ring 148 includes an outside flange 152 having a top face 154 facing the extending bladder 170 and a bottom face 156 facing the series of compression springs 172. The backing ring 148 has an inside flange 150 having a lower face 151 which extends inwardly over the diameter of the wafer backing member 124a such that when the backing member 124a is raised beyond a certain point the backing ring assembly 146 also rises.

Figures 4 and 5 show details of the wafer perimeter retainer ring assembly 146. The wafer perimeter retaining ring backing ring 148 is urged upwardly away from the lip 110 of the descending wall 104 by a plurality of (for example 6-12) compression springs 172. When the extending bladder 170 is pressurized to extend the retaining ring assembly 146 to its operating position as shown by the dash lines 146a in Figure 4, the wafer perimeter retaining ring 162 surrounds the edge of wafer being polished 142. This prevents the wafer from sliding out from under the wafer backing member 124, or 124a. Inflation of the bladder 170 through the gas passage 171

provides a downward force to oppose the compression springs 172 and forces the retaining ring 162 toward and possibly against the polishing pad 182. A continuous continuously pressurized bladder could be employed to replace the series of springs 172 to provide a uniformly distributed retracting forces.

The lower surface 151 of the backing ring inside flange 150 is configured so that as the plastic Delrin material of the wafer perimeter retaining ring 162 wears away, the travel of retaining ring is limited by the interference between the lower surface 151 of the upper flange 150 and the top of the wafer backing member 124a so that the head of the retaining ring retaining screws 168 cannot touch the polishing pad. This prevents the heads of retaining screws 168 from coming in contact with the polishing pad and introducing undesirable contaminants. The perimeter retaining ring can also be mounted without screws, such as by use of key slots requiring insertion and partial rotation to retain the key and opposing grooves having O-rings sized to engage and span the space between grooves.

While the invention has been described with regard to specific embodiments, those skilled in the art will recognize that changes can be made in form and detail without departing from the spirit and scope of the invention.

Claims

1. An apparatus for holding a substrate during polishing comprising:

   a polishing head substrate backing member having a substrate facing side, said substrate facing side including a seal to generally fluid tightly seal the member to the perimeter of the substrate being polished, said member including a fluid supply passage therethrough opening to the confines of a pocket formed between the substrate and said substrate facing side of the member within the boundary of said seal.

2. An apparatus for holding a substrate during polishing as in Claim 1,

   wherein said seal is an elastomeric material such that when said seal is pressed against the substrate during polishing of the substrate, thereby pressing the substrate to a polishing pad, the contact between the substrate facing side including said seal and the perimeter of said substrate when the head is rotated provides a frictional force between said substrate facing side and the perimeter of the substrate so that said substrate generally turns with said head.

3. An apparatus for holding a substrate during polishing as in Claim 1,

   wherein said polishing head substrate backing member is supported from a polishing head housing support member through a pressure containing bellows.

4. An apparatus for holding a substrate during polishing as in Claim 2,

   wherein said polishing head substrate backing member is supported from a polishing head housing support member through a pressure containing bellows.

5. An apparatus for holding a substrate during polishing comprising:

   a polishing head substrate backing member supported from a polishing head housing support member;

   a substrate retaining ring assembly surrounding said substrate backing member, said ring assembly being separate from and movable relative to said substrate backing member and separate from and movable relative to said housing support member;

   wherein said housing support member is connected to said retaining ring assembly by a first set of one or more elastic members which elastically urge the retaining ring assembly to retract away from a polishing face of said polishing head substrate backing member;

   wherein said housing support member is connected to said retaining ring assembly by a second set of one or more elastic members which elastically urge the retaining ring assembly to extend towards the polishing face of said polishing head substrate backing member;

   wherein either said first set or said second set of elastic members is configured to increase or to decrease a magnitude of the force associated with the elastic urge between said housing support member and said retaining ring assembly thereof.

6. An apparatus for holding a substrate during polishing as in Claim 5,

   wherein said first set of one or more elastic members is a set of springs generally equally distributed around said substrate backing member.

7. An apparatus for holding a substrate during polishing as in Claim 5,

   wherein said second set of one or more elastic members is an annular bladder around said substrate backing member, wherein said bladder is pressurized to increase the magnitude of the force associated with the elastic urge between said housing support member and said retaining ring assembly causing the retaining ring assembly to extend towards the polishing face of said polishing head

substrate backing member.

8. An apparatus for holding a substrate during polishing as in Claim 1, further comprising:

the polishing head substrate backing member supported from a polishing head housing support member;
a substrate retaining ring assembly surrounding said substrate backing member, said ring assembly being separate from and movable relative to said substrate backing member and separate from and movable relative to said housing support member;
wherein said housing support member is connected to said retaining ring assembly by a first set of one or more elastic members which elastically urge the retaining ring assembly to retract away from a polishing face of said polishing head substrate backing member;
wherein said housing support member is connected to said retaining ring assembly by a second set of one or more elastic members which elastically urge the retaining ring assembly to extend towards the polishing face of said polishing head substrate backing member;
wherein either said first set or said second set of elastic members is configured to increase or to decrease a magnitude of the force associated with the elastic urge between said housing support member and said retaining ring assembly thereof.

9. An apparatus for holding a substrate during polishing as in Claim 8,

wherein said first set of one or more elastic members is a set of springs generally equally distributed around said substrate backing member.

10. An apparatus for holding a substrate during polishing as in Claim 8,

wherein said second set of one or more elastic members is an annular bladder around said substrate backing member, wherein said bladder is pressurized to increase the magnitude of the force associated with the elastic urge between said housing support member and said retaining ring assembly causing the retaining ring assembly to extend towards the polishing face of said polishing head substrate backing member.

11. An apparatus for holding a substrate during polishing comprising:

a polishing head substrate backing member including a pressurizable pocket open to and facing a back surface of the substrate to be polished, a perimeter of said pocket being sealable to the back of said substrate, the pocket including an opening therein for controlling the pressure within the pocket by the use of fluid passing into and out of said pocket through said opening.

12. An apparatus for holding a substrate during polishing as in Claim 11, further comprising

a bellows member, wherein said polishing head substrate backing member is supported from a polishing head housing support member through the bellows member which in use provides a generally uniform force pressing the polishing head backing member toward a polishing pad generally irrespective of changes in the distance between the polishing head housing support member and the polishing pad as the polishing head pressing the substrate to be polished toward the polishing pad moves relative to the polishing pad.

13. An apparatus for holding a substrate during polishing as in Claim 11, further comprising

a floating substrate retaining ring member assembly configured in use to generally surround said substrate to be polished to prevent the substrate, being pressed toward said polishing pad by said polishing head backing member, from sliding sideways beyond an inner boundary set for the substrate by said retaining ring member,
wherein said substrate retaining ring member in use is urged toward the polishing pad by an first urging member located between the housing support member and the ring member assembly causing a portion of said retaining ring member to contact said polishing pad, and said retaining ring member is configured to interfere with a portion of said housing support member to prevent relative side motion between the retaining ring member and said housing support member,
wherein said substrate retaining ring member is urged away from said polishing pad by a second urging member connected between the housing support member and the ring member assembly, such that said first urging member in a first mode creates a first urging force overcoming said urging force created by said second urging member and in a second mode creates a second urging force which does not overcome said urging force created by said second urging member.

14. An apparatus for holding a substrate during polishing as in Claim 12, further comprising

a floating substrate retaining ring member assembly configured in use to generally surround said substrate to be polished to prevent the

substrate, being pressed toward said polishing pad by said polishing head backing member, from sliding sideways beyond an inner boundary set for the substrate by said retaining ring member,
wherein said substrate retaining ring member in use is urged toward the polishing pad by an first urging member located between the housing support member and the ring member assembly causing a portion of said retaining ring member to contact said polishing pad, and said retaining ring member is configured to interfere with a portion of said housing support member to prevent relative side motion between the retaining ring member and said housing support member.
wherein said substrate retaining ring member is urged away from said polishing pad by a second urging member connected between the housing support member and the ring member assembly, such that said first urging member in a first mode creates a first urging force overcoming said urging force created by said second urging member and in a second mode creates a second urging force which does not overcome said urging force created by said second urging member.

15. An apparatus for holding a substrate during polishing comprising

a bellows member, wherein said polishing head substrate backing member is supported from a polishing head housing support member through the bellows member which in use provides a generally uniform force pressing the polishing head backing member toward a polishing pad generally irrespective of changes in the distance between the polishing head housing support member and the polishing pad as the polishing head pressing the substrate to be polished toward the polishing pad moves relative to the polishing pad.

16. An apparatus for holding a substrate during polishing as in Claim 15, further comprising

a floating substrate retaining ring member assembly configured in use to generally surround said substrate to be polished to prevent the substrate, being pressed toward said polishing pad by said polishing head backing member, from sliding sideways beyond an inner boundary set for the substrate by said retaining ring member,
wherein said substrate retaining ring member in use is urged toward the polishing pad by an first urging member located between the housing support member and the ring member assembly causing a portion of said retaining ring member to contact said polishing pad, and said retaining ring member is configured to interfere with a portion of said housing support member to prevent relative side motion between the retaining ring member and said housing support member,
wherein said substrate retaining ring member is urged away from said polishing pad by a second urging member connected between the housing support member and the ring member assembly, such that said first urging member in a first mode creates a first urging force overcoming said urging force created by said second urging member and in a second mode creates a second urging force which does not overcome said urging force created by said second urging member.

17. An apparatus for holding a substrate during polishing comprising

a floating substrate retaining ring member assembly configured in use to generally surround said substrate to be polished to prevent the substrate, being pressed toward said polishing pad by said polishing head backing member, from sliding sideways beyond an inner boundary set for the substrate by said retaining ring member,
wherein said substrate retaining ring member in use is urged toward the polishing pad by an first urging member located between the housing support member and the ring member assembly causing a portion of said retaining ring member to contact said polishing pad, and said retaining ring member is configured to interfere with a portion of said housing support member to prevent relative side motion between the retaining ring member and said housing support member,
wherein said substrate retaining ring member is urged away from said polishing pad by a second urging member connected between the housing support member and the ring member assembly, such that said first urging member in a first mode creates a first urging force overcoming said urging force created by said second urging member and in a second mode creates a second urging force which does not overcome said urging force created by said second urging member.

18. A process for polishing a substrate on a polishing pad comprising the steps of:

placing the substrate in contact with a polishing head backing member, wherein the polishing head backing member includes a pocket facing

the back of the substrate, said member including a perimeter seal surrounding said pocket to form a generally fluid tight seal with said substrate in contact with said seal;
positioning the substrate in contact with the polishing head backing member against a polishing pad;
urging the polishing head backing member toward the polishing pad using a generally uniform force;
controlling the fluid pressure in said pocket; and
moving said substrate relative to the polishing pad to polish said substrate as the substrate rubs against a surface of a polishing pad.

19. A process for polishing a substrate in a polishing pad as in Claim 18;

wherein the fluid pressure in said pocket achieves blow by conditions when the force urging the polishing head backing member toward the polishing pad causing the perimeter seal to seal against the substrate is overcome by the pressure in the pocket creating a force large enough to separate the substrate from the polishing head backing member and cause the fluid pressurizing the pocket to leak across the seal, and wherein the step of controlling the fluid pressure in said pocket further includes the step of controlling the fluid pressure in the pocket to a pressure near to, but less than blow by conditions.

20. A process for polishing a substrate on a polishing pad as in Claim 18 further comprising the step of

restricting the sideways movement of the substrate relative to the polishing head backing member by providing a retaining ring encircling the substrate positioned against the polishing head backing member and which in use extends to and is urged against the surface of the polishing pad.

21. A process for polishing a substrate on a polishing pad as in Claim 19 further comprising the step of

restricting the sideways movement of the substrate relative to the polishing head backing member by providing a retaining ring encircling the substrate positioned against the polishing head backing member and which in use extends to and is urged against the surface of the polishing pad.

22. A polishing head for positioning a surface of a substrate against a polishing member and providing a force on the substrate against the polishing surface, wherein the substrate includes a first surface thereon which is positionable against the pad for polishing and a second surface thereon disposed generally planar to the first surface, comprising:

a substrate mounting member having a substrate receiving surface including a seal extendable therefrom and positionable against the second surface of the wafer; and
a pocket formed between the substrate and said mounting member.

23. The polishing head of claim 22,

wherein said mounting member includes an annular extending portion which circumscribes a pocket; and
said seal provides a sealing interface between said annular extending portion and the second surface of the substrate.

24. The polishing head of claim 23, further including a pressurizable chamber disposed therein.

25. The polishing head of claim 24, wherein the polishing head is supported on the polishing surface by a support extendable at least partially over the polishing surface.

26. The polishing head of claim 25, wherein said chamber, when subjected to a pressure above atmospheric pressure, provides a force to load the substrate against the polishing surface.

27. The polishing head of claim 23, wherein said pocket is maintainable at a vacuum pressure to maintain the substrate in contact with the head when the substrate is not positioned on the polishing surface.

28. The polishing head of claim 27, further including a pressure source ported to said pocket.

29. The polishing head of claim 27, further including a pressure source ported to said chamber.

30. The polishing head of claim 27, further including a vacuum source ported to said pocket.

31. The polishing head of claim 22, further including a retainer at least partially circumscribing said mounting member and selectively positionable with respect to said substrate receiving surface.

32. The polishing head of claim 31, further including

a retainer support member; and
a first biasing member extendable between said retainer support member and said retainer.

33. The polishing head of claim 32, further including a second biasing member extending between said retainer support and said retainer.

34. The polishing head of claim 33, wherein said sec-

ond biasing member provides a controllable, variable, bias on said retainer to extend said retainer outwardly of the position of said substrate receiving portion.

35. The polishing head of claim 34, wherein said second biasing member includes at least one pressurizable bladder.

36. The polishing head of claim 32, wherein said first biasing member includes at least one spring.

37. The polishing head of claim 23, wherein said seal circumscribes said substrate receiving portion and extends outwardly therefrom.

38. The polishing head of claim 37, wherein said seal is a lip seal.

39. A method of polishing a surface of a substrate, wherein the substrate includes a first surface to be polished and a second surface disposed generally parallel thereto, comprising the steps of:

providing a polishing head having a mounting portion thereon to receive the second surface of the substrate and position the first surface of the substrate on a polishing surface;
forming a pocket between the substrate and the mounting portion by positioning the second surface of the substrate against the mounting portion;
selectively varying the pressure in the pocket.

40. The method of claim 39, wherein a pressure above atmospheric is maintained in the pocket during polishing of the substrate.

41. The method of claim 39, further including the steps of evacuating the pocket to a pressure below atmospheric pressure when the substrate is removed from the polishing surface.

42. The method of claim 39, including the further steps of:

positioning the carrier over the polishing surface on a support member;
providing a chamber within the polishing head; and
selectively pressurizing the chamber to provide a load force at the interface of the first surface and the polishing surface.

43. The method of claim 42, further including the steps of:

positioning the substrate on a polishing surface with the polishing head;
pressurizing the chamber to a first pressure to provide a contact pressure at the interface of the substrate second surface and the mounting portion; and
pressurizing the pocket to reduce the contact pressure at the interface of the substrate and the mounting portion while simultaneously providing a uniform force load at the interface of the substrate and the polishing surface.

44. The method of claim 43, wherein the pressure in the pocket is insufficient to reduce the contact pressure between the substrate and the mounting portion below the pressure needed to maintain a frictional force maintaining the substrate in contact with the mounting portion as the mounting portion moves.

45. The method of claim 43, wherein the pressure in the pocket is insufficient to reduce the contact pressure between the substrate and the mounting portion to zero pressure.

46. The method of claim 39, further including the steps of:

providing a pocket in the mounting portion;
providing an annular portion about the perimeter of the pocket to form a mounting surface against which the second surface of the substrate may be positioned.

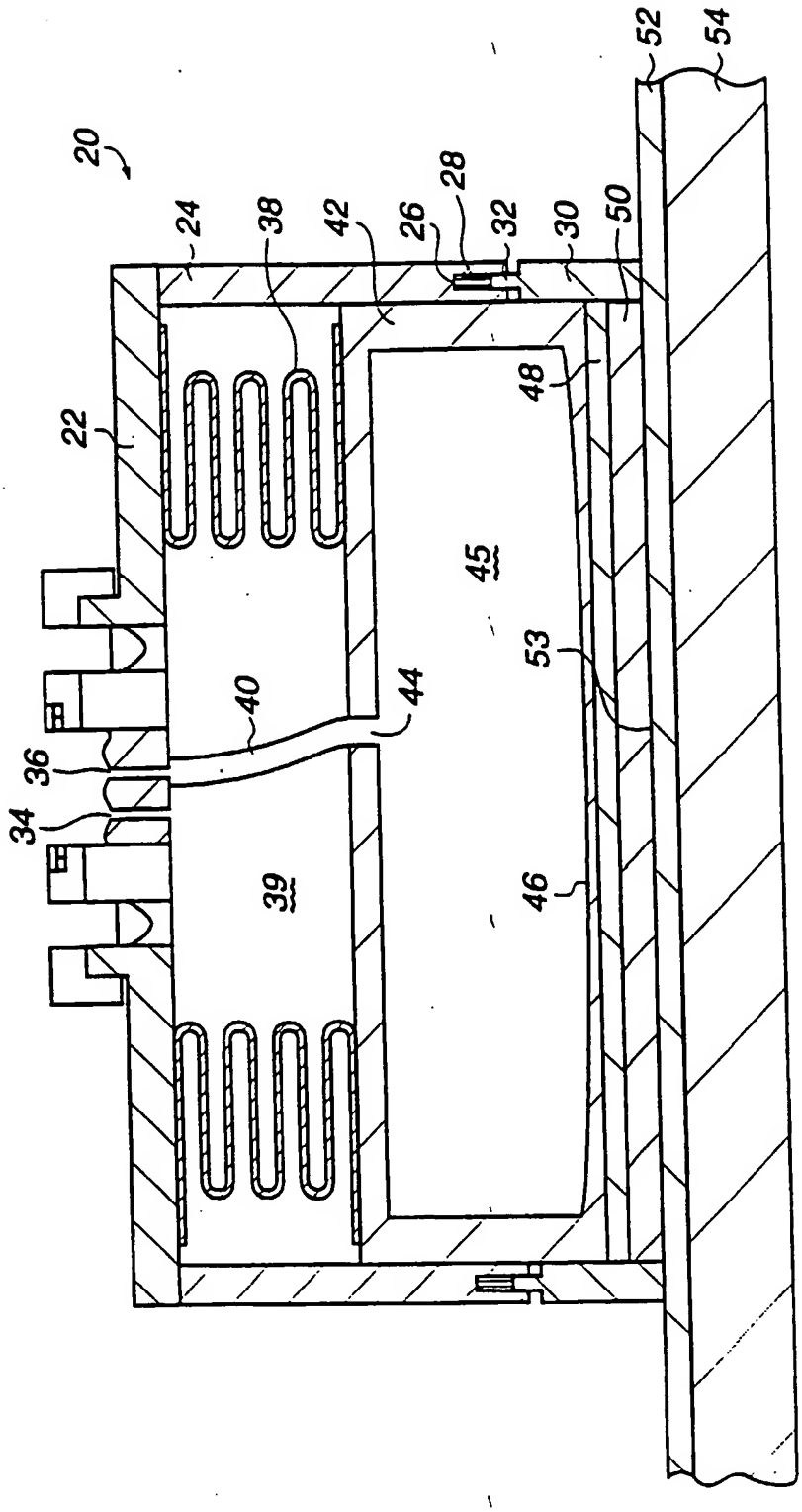

Fig. 1

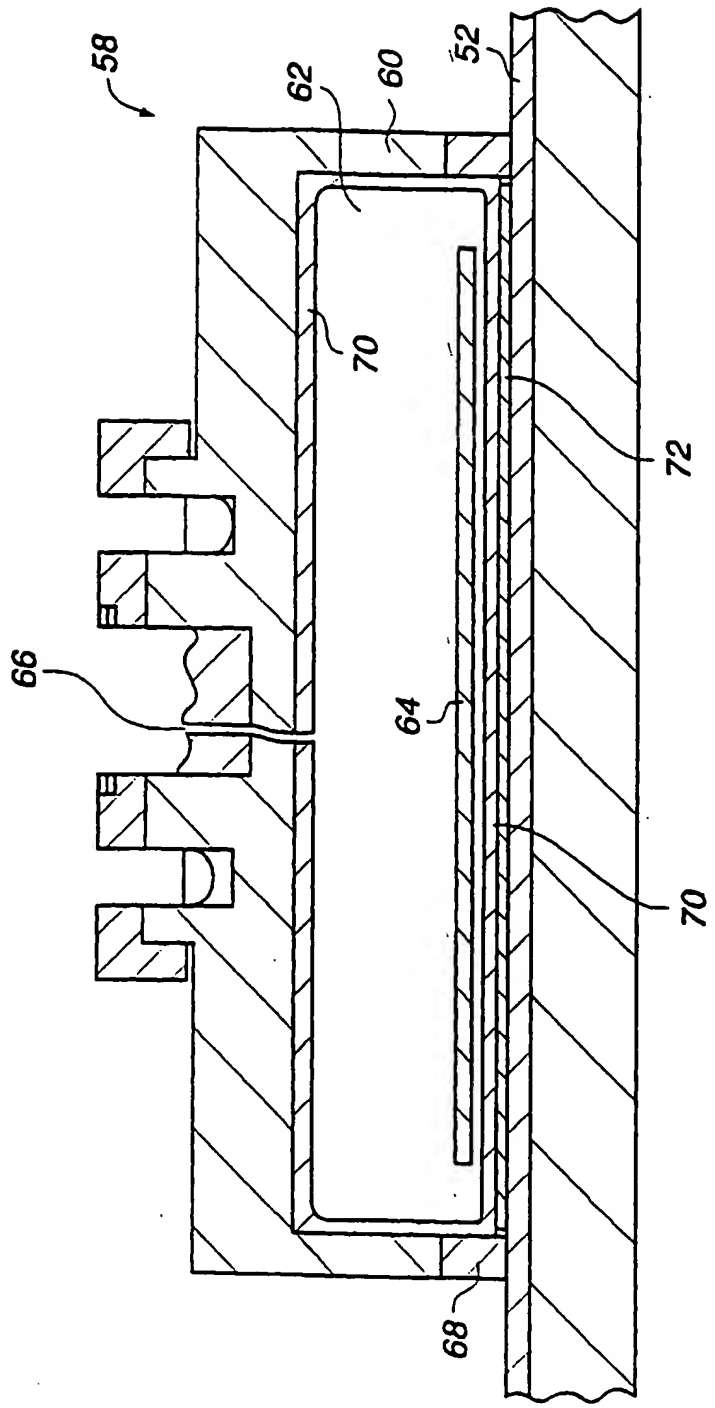

Fig. 2

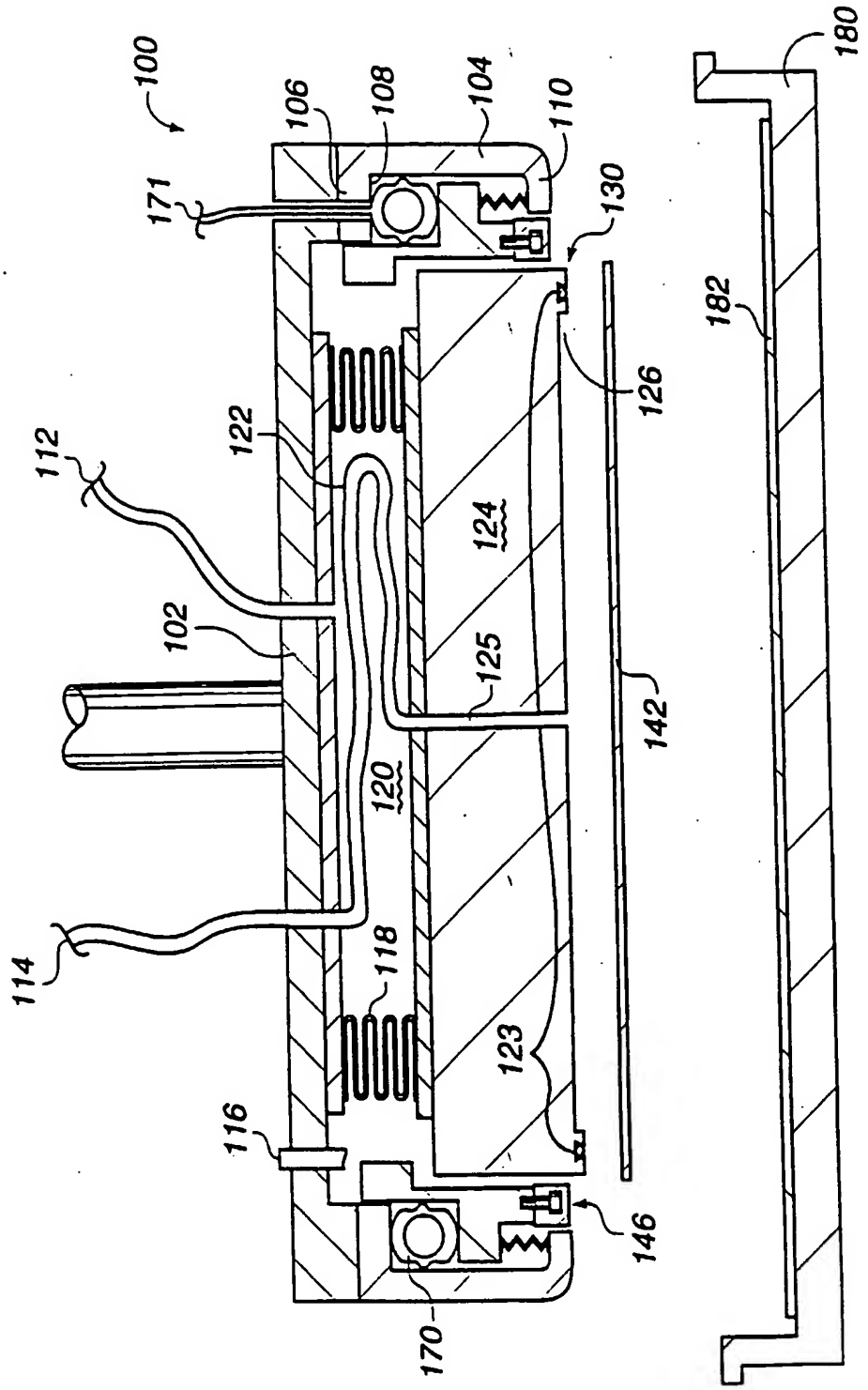

Fig. 3

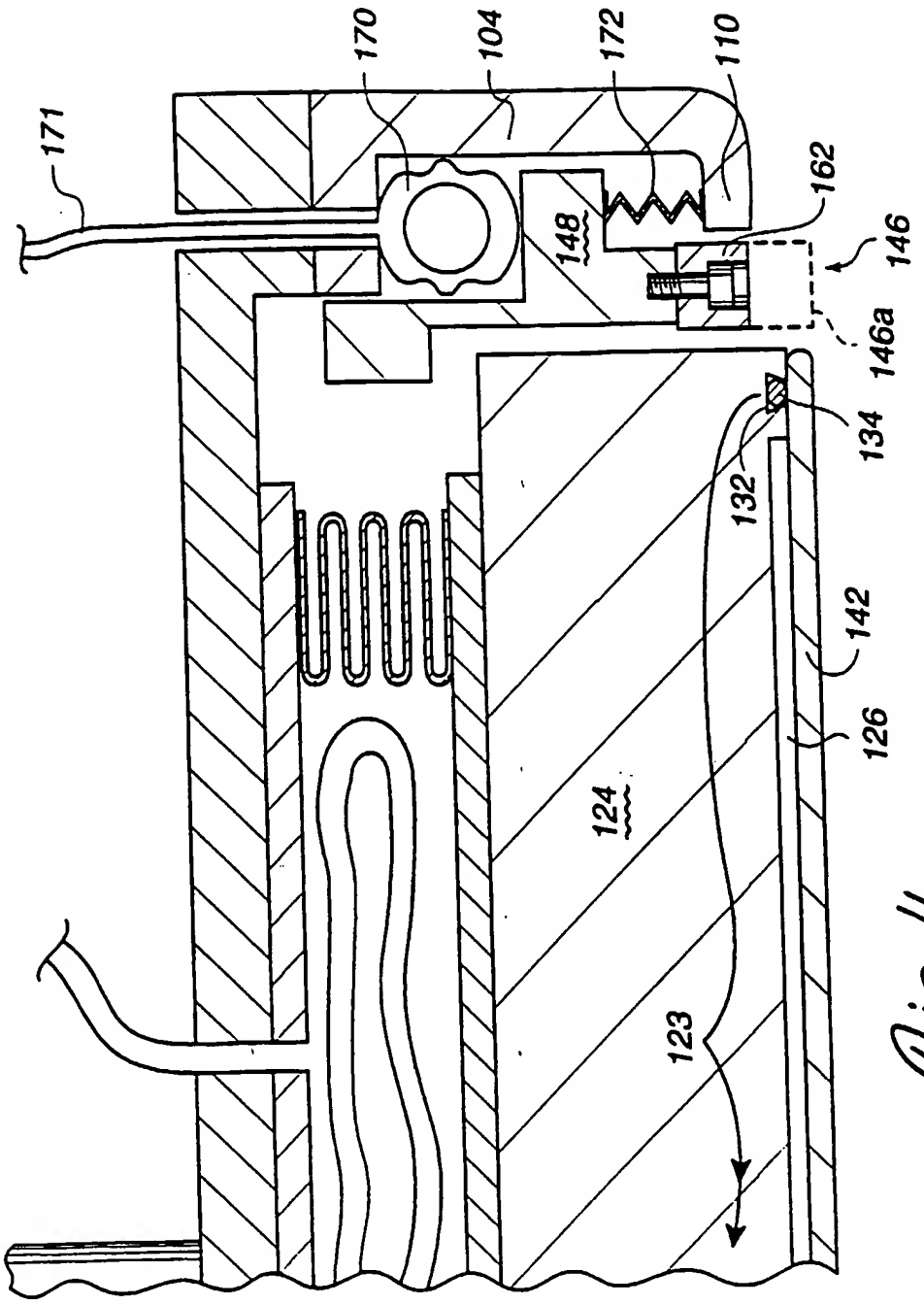

Fig. 4

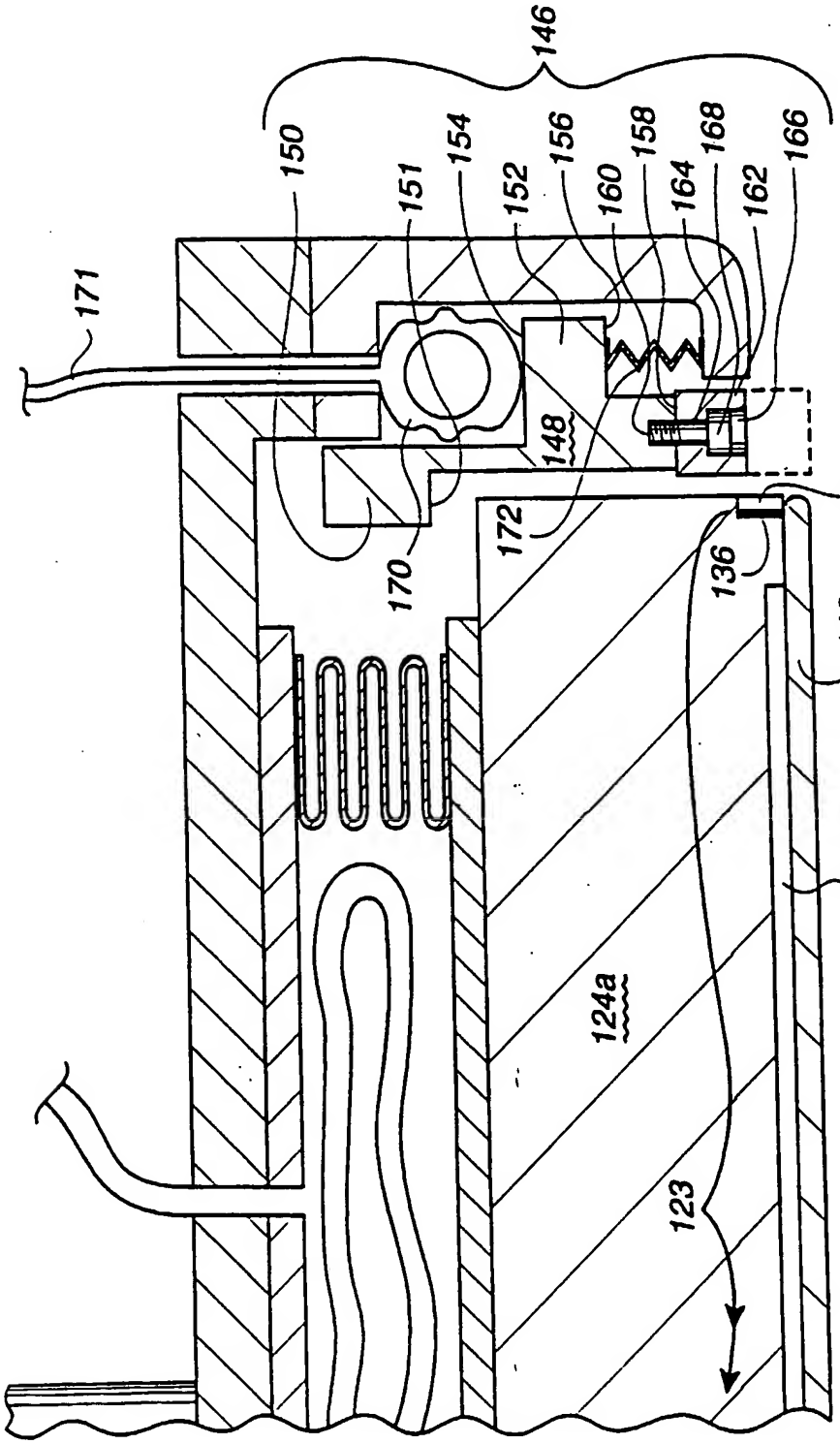

Fig. 5